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WILDFIRE AND SOIL ORGANIC CARBON IN SAGEBRUSH–BUNCHGRASS VEGETATION

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Soil organic matter is an important component of the environment for plants, one that enhances availability of water and nutrients (Nelson and Sommers 1982), contributes to a suitable seedbed (Monsen and McArthur 1985), and enhances seedling emergence (Wood et al. 1978). In the sagebrush region of the Intermountain West, loss of organic matter due to recurring wildfire may be a mechanism of long-term site degradation, ultimately caused by excessive livestock grazing and the introduction of aggressive annual plants (West 1988). Loss of organic matter or plant cover due to fire may increase erosion and decrease infiltration, thereby decreasing seedbed quality (Monsen and McArthur 1985). Loss of organic matter may also render soils less friable and more likely to form crusts upon drying, and so increase the resistance emerging seedlings must overcome (Wood et al. 1978). On the other hand, it is conceivable that the increase of the introduced annual cheatgrass (*Bromus tectorum* L.) that may follow wildfire (West 1988) may increase soil organic matter over the long run, due to litter accumulation. Documentation of the response of soil organic matter to wildfire in the sagebrush region is limited. On relatively mesic big sagebrush (*Artemisia tridentata* Nutt.) sites, the occurrence of a single fire apparently does not decrease organic matter in the surface soil layers (Nimir and Payne 1978, Humphrey 1984). This study concerns the effect of wildfire on soil organic matter in relatively xeric big sagebrush sites (Acker 1988).

METHODS

I studied soil organic matter at two pairs of burned and adjacent unburned big sagebrush–bunchgrass stands in northern Harney County, Oregon, USA. The stands were selected along with seven other pairs for a study of post-wildfire big sagebrush–bunchgrass vegetation dynamics (Acker 1988). I selected as study stands burned and adjacent unburned areas in which at least one of four climax bunchgrass species was present (bluebunch wheatgrass, *Agropyron spicatum* [Pursh] Scribn. & Smith; Indian ricegrass, *Oryzopsis hymenoides* [R. & S.] Ricker; needle-and-thread, *Stipa comata* Trin. & Rupr.; and Thurber's needlegrass, *Stipa thurberiana* Piper) (Hironaka et al. 1983). The climate is semiarid (28.9 cm annual precipitation on average for Burns, Oregon, about 40 km north of the study area), with hot, dry summers and cold winters (Franklin and Dyrness 1973). Soils are stony and shallow over lava or welded ash deposits, and are classified as Lithic Xerollic Haplargids mixed with Lithic Torriorthents (Lindsay et al. 1969). Within pairs, the sites are similar in elevation, slope, aspect, and surface soil texture (Table 1). Other than incidental use, none of the four stands was grazed by domestic livestock during this study or over several decades (M. Armstrong, personal communication). Shrub skeletons were present on all the burned stands. Thus, prior to the recent fires, paired stands probably had similar fire histories. The initial wildfire occurred in August 1981. The stands were sampled in the early summer

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TABLE 1. Environmental, historical, and vegetation data for burned (odd numbers) and adjacent unburned (even numbers) big sagebrush–bunchgrass stands, Harney County, Oregon, USA. Soil texture determined by method of Liegel et al. (1980).

Stand number	Elev. (m)	Aspect category[a]	Slope (%)	Soil texture, top 10 cm	Dominant plant species (1985)[b]
1	1325	9	17	sandy loam	BRTE, ERFI, POSE, PHHO, ORHY
2	1325	8	12	sandy loam	ARTRW, PHHO, ASFI
3	1360	3	19	loamy sand	BRTE, STCO2, CHVI
4	1360	2	22	loamy sand	ARTRT, BRTE, CHNA

[a]1 = SSW, 2 = S,SW, 3 = SSE,WSW, 4 = SE,W, 5 = ESE,WNW, 6 = E,NW, 7 = ENE,NNW, 8 = NE,N, 9 = NNE (based on Muir and Lotan 1985). Categories 1–4 are warm aspects; categories 5–9 are cool aspects.
[b]Plants with at least 3% cover, in descending order. ARTRT = *Artemisia tridentata* ssp. *tridentata*, ARTRW = *Artemisia tridentata* ssp. *wyomingensis*, ASFI = Astragalus filipes; BRTE = *Bromus tectorum*, CHNA = *Chrysothamnus nauseosus* ssp. *albicaulis*, CHVI = *Chrysothamnus viscidiflorus* ssp. *viscidiflorus*, ERFI = *Erigeron filifolius*, ORHY = *Oryzopsis hymenoides*, PHHO = *Phlox hoodii*, POSE = *Poa secunda*, STCO2 = Stipa comata. Voucher specimens on file at University of Wisconsin—Madison Herbarium.

TABLE 2. Comparison of organic carbon in top 10 cm of soil in burned and adjacent unburned big sagebrush–bunchgrass stands, northern Harney County, Oregon, USA. Values are mean percentages of mass of oven-dried soil (standard errors in parentheses). Standard errors were computed using each stand's variance for 1987 and the number of subsamples for the year listed (Petersen and Calvin 1986). The number of degrees of freedom for all tests is 30 (E. Nordheim, personal communication).

Year	Organic carbon		N	Result of two-tailed *t* test, burned vs. unburned
		Stands 1 and 2		
1985	burned:	1.19 (0.24)	3	$.4 > P > .2$, NS[a]
	unburned:	0.83 (0.23)	3	
1986	burned:	1.17 (0.21)	4	$P > .5$, NS
	unburned:	1.34 (0.20)	4	
1987	burned:	1.31 (0.10)	16	$.4 > P > .2$, NS
	unburned:	1.15 (0.10)	16	
		Stands 3 and 4		
1985	burned:	0.63 (0.17)	3	$P > .5$, NS
	unburned:	0.68 (0.16)	3	
1986	burned:	0.60 (0.15)	4	$P > .5$, NS
	unburned:	0.65 (0.14)	4	
1987[b]	burned:	0.83 (0.07)	16	$P > .5$, NS
	unburned:	0.84 (0.07)	16	

[a]Not significant
[b]Both stands 3 and 4 burned between the 1986 and 1987 samplings.

of 1985, 1986, and 1987. Stands 3 and 4 burned again in a wildfire September 1986.

I collected samples from the top 10 cm of soil, 3 samples per stand in 1985, 4 in 1986, and 16 in 1987. In the first two years sampling locations were laid out in a systematic manner. In 1987 samples were collected in a stratified random manner. The randomization for the only remaining unburned stand, stand 2, was further restricted so that the area under shrub canopies was sampled roughly in proportion to the cover of shrubs in the stand. Shrubs can influence spatial patterns of soil chemistry in big sagebrush vegetation (Doescher et al. 1984).

Organic matter of the soil samples was assessed using the Walkley-Black rapid dichromate oxidation method of organic carbon determination (Nelson and Sommers 1982). I used the standard correction factor of 1.3 to adjust for organic carbon not oxidized in the procedure. Given the uncertain quantitative relationship between soil organic carbon and soil organic matter, I report soil organic carbon, as Nelson and Sommers recommend (1982).

I used two-tailed *t* tests to compare organic carbon between paired stands (Sokal and Rohlf 1981). For 1985 and 1986 I used the sample variance from the 1987 observations and the sample size from the year in question to determine the denominator of the test statistic (Petersen and Calvin 1986). This was done due to the larger sample size and the (stratified) random arrangement of the 1987 samples (Greig-Smith 1983). In the strictest sense, these observations can only establish differences between adjacent stands. Applying these results to burned and unburned big sagebrush–bunchgrass stands more generally is tenuous, due to the lack of replication (Hurlbert 1984).

Results and Discussion

For both pairs of stands there was no significant difference in organic carbon in the top 10 cm of soil in any of the three years (Table 2). None of the individual comparisons is suggestive of such a difference ($P > .20$ in all cases). Although I did not test statistically for a temporal trend, soil organic carbon does not appear to have changed over the course of the study in any of the stands. Thus, the recurrence of fire at stands 3 and 4 does not appear to have altered soil organic carbon.

Changes in organic matter are by no means the only ecologically important soil changes wildfire may cause in big sagebrush vegetation (e.g., increase of organic acids in burned soil; Blank and Young 1990). Furthermore, the short duration and small sample size limit the generality of conclusions. However, these stands are not unlike others in the general vicinity where climax bunchgrasses persist (Acker 1988). In addition, these stands offer a rare opportunity to observe big sagebrush–bunchgrass vegetation processes in the absence of livestock grazing.

Wildfire apparently has not decreased or increased soil organic matter on these stands. From other studies, I have concluded that post-wildfire vegetation dynamics in these stands and similar ones nearby is dominated by cheatgrass and does not feature increasing abundance of climax bunchgrasses (Acker 1988). To explain these trends may require invoking something other than irreversible site degradation, as indicated by loss of soil organic matter.

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